Scanning Coherent X-ray Diffraction Imaging of GdFe Magnetic Multilayers

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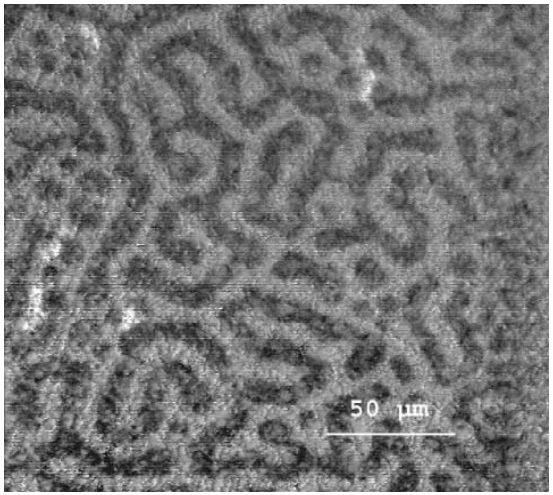
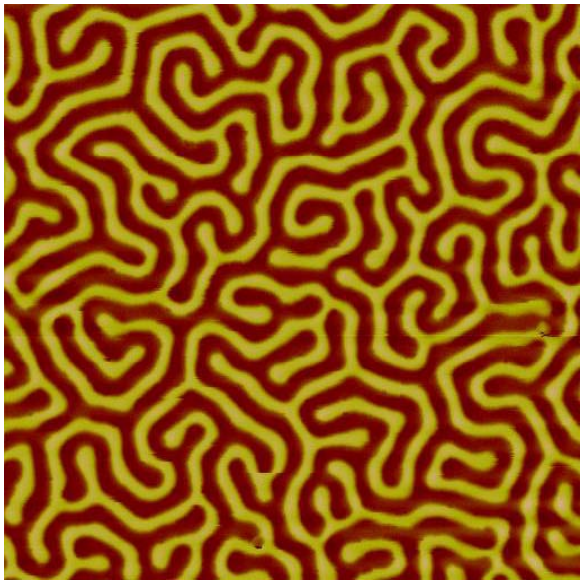
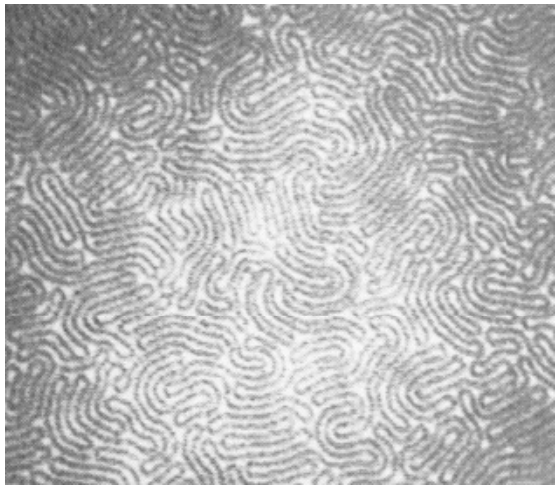
Pattern Formation



Superconducting domains.
Gourdon, C. et al. Appl Phys Lett. **82** 230 (2003)

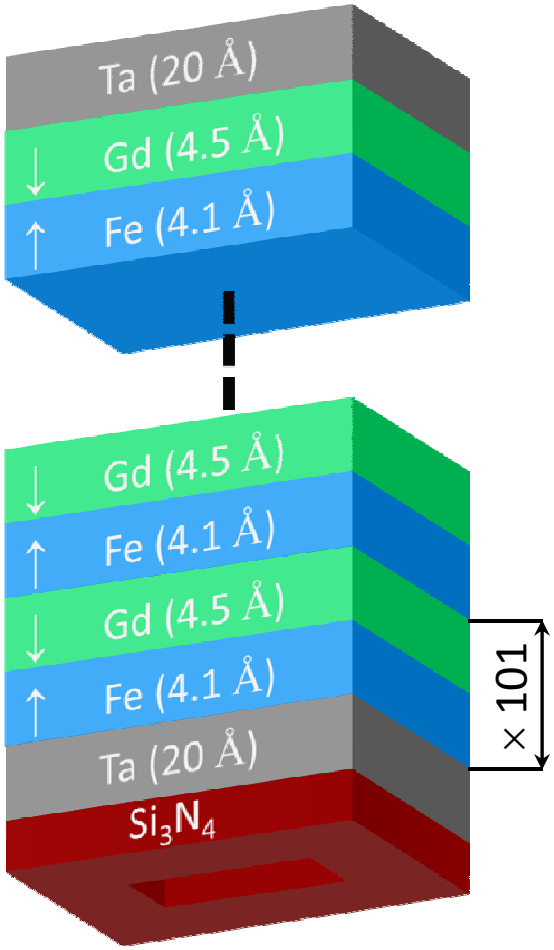


Magnetic Domains

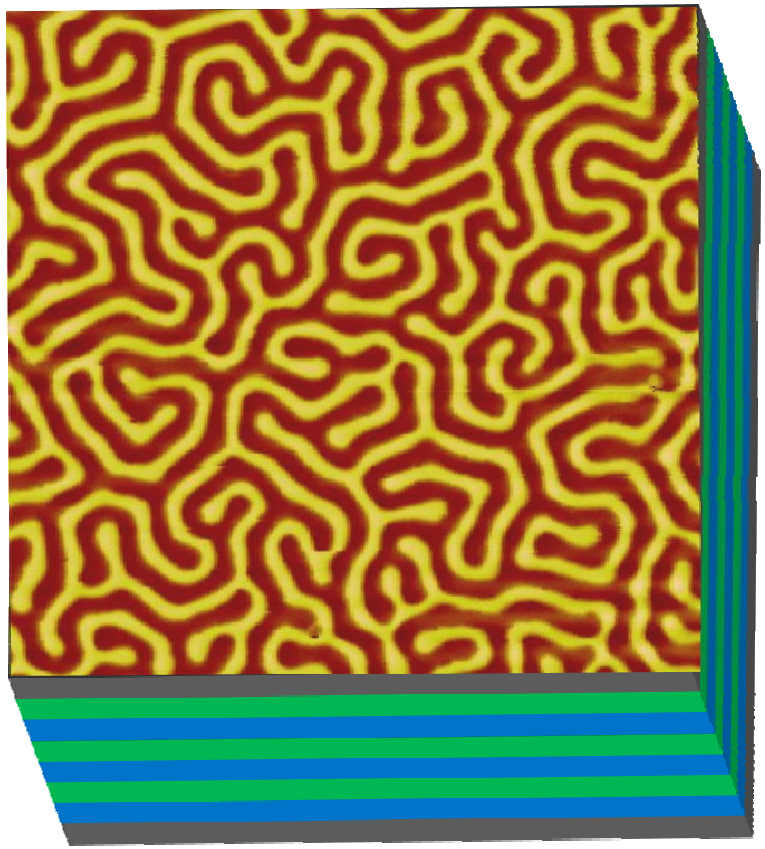


Langmuir Monolayer.
Stine, K. et al. Langmuir. **8** 2509 (1992)

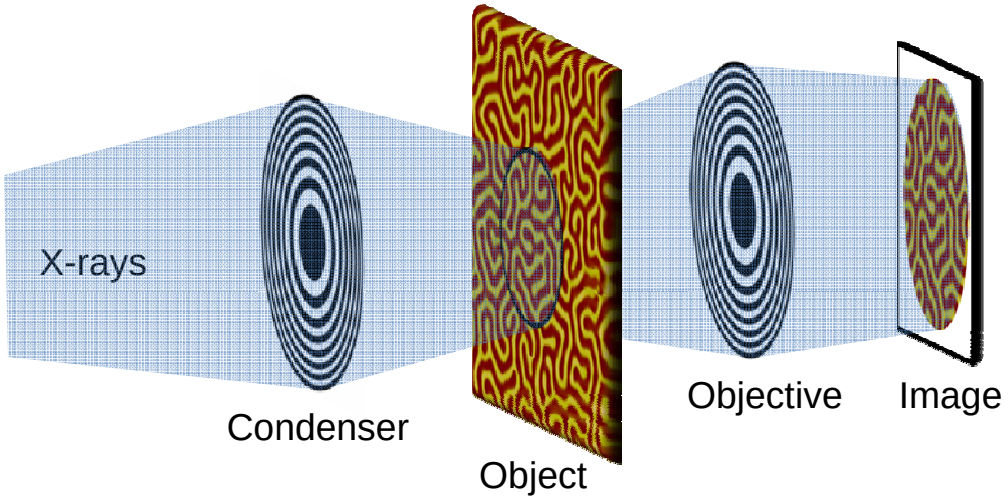
GdFe layered thin film



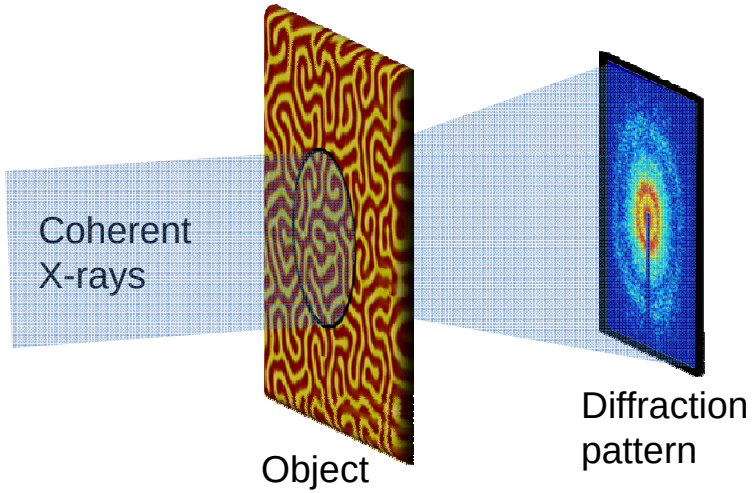
MFM image of GdFe magnetic domains.



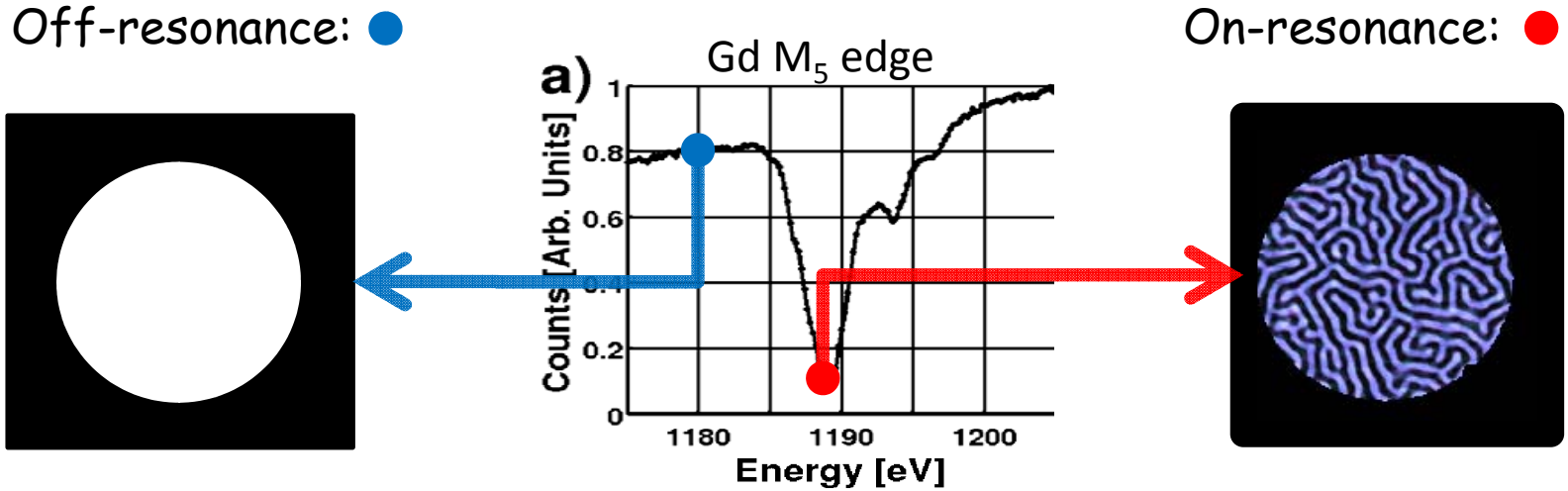
X-ray Imaging

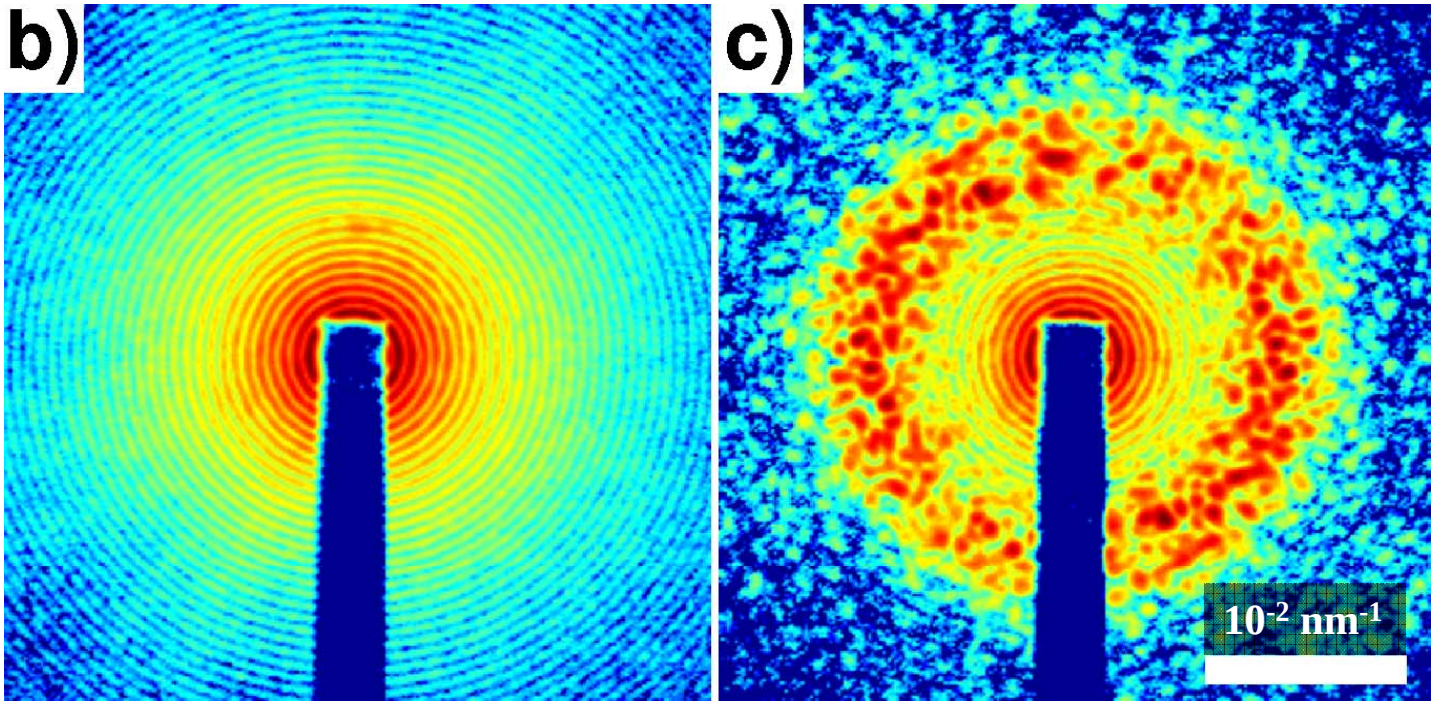


Scanning Transmission X-ray Microscopy

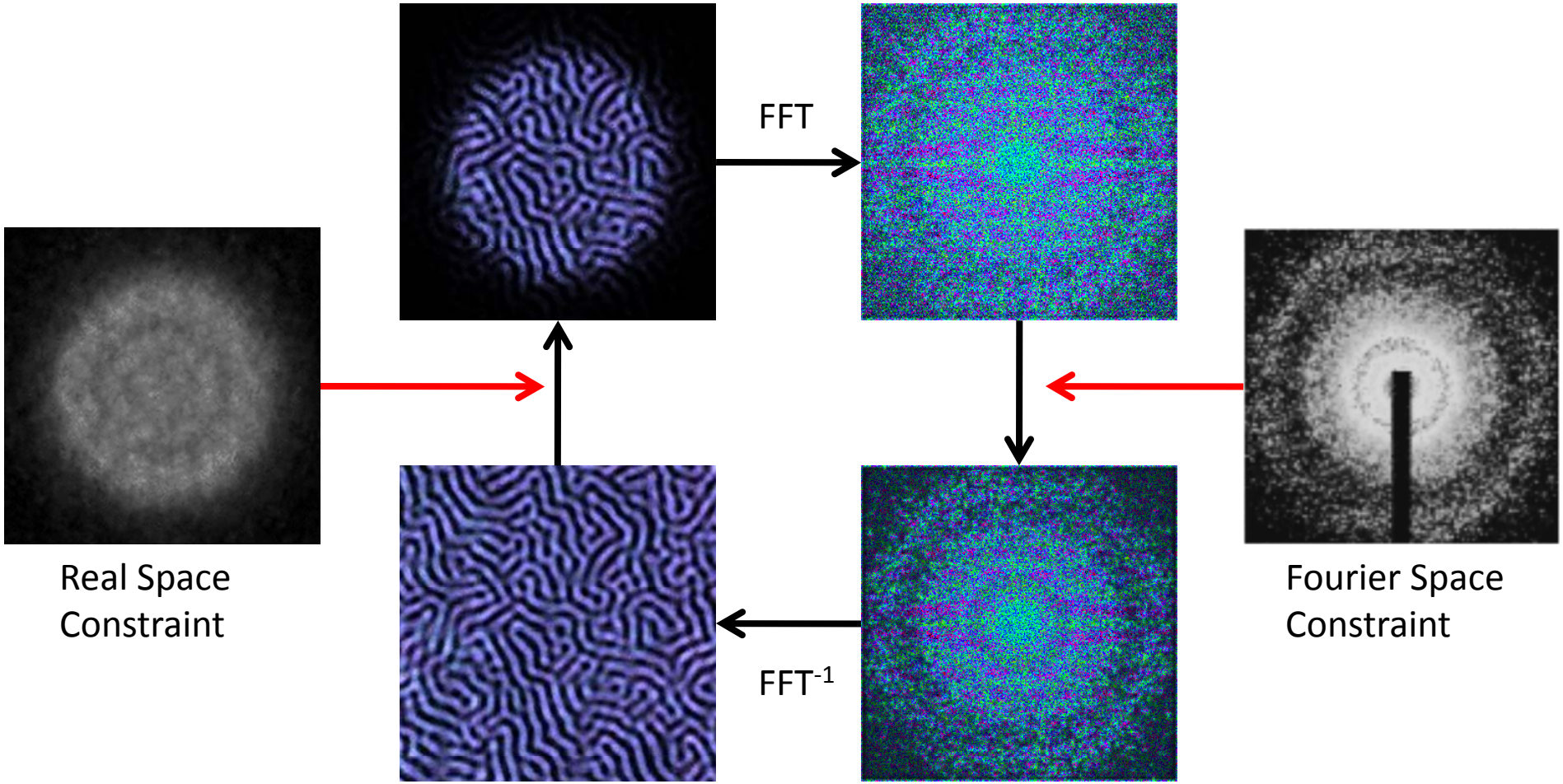


Coherent Diffractive Imaging

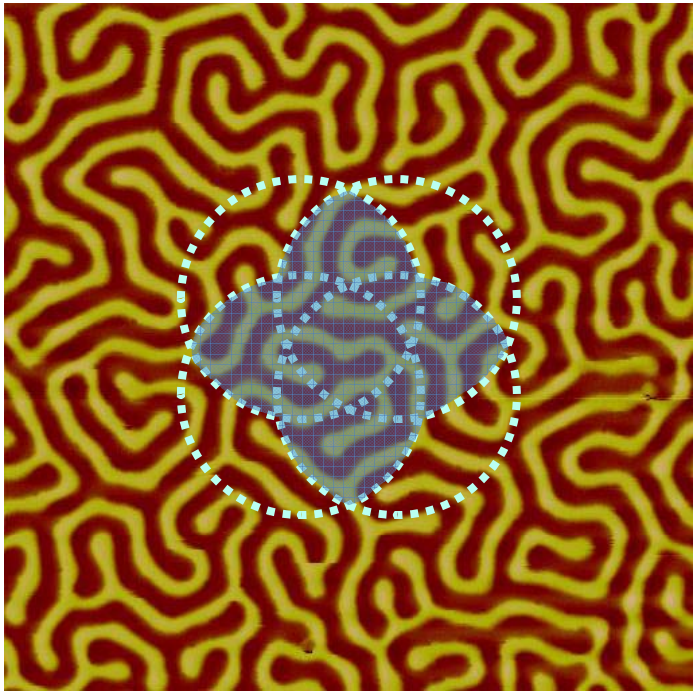

Off-resonance:
On-resonance:
a)
Gd M5 edge
Counts [Arb. Units]
Energy [eV]
1180
1190
1200
0
0.2
0.6
0.8
1

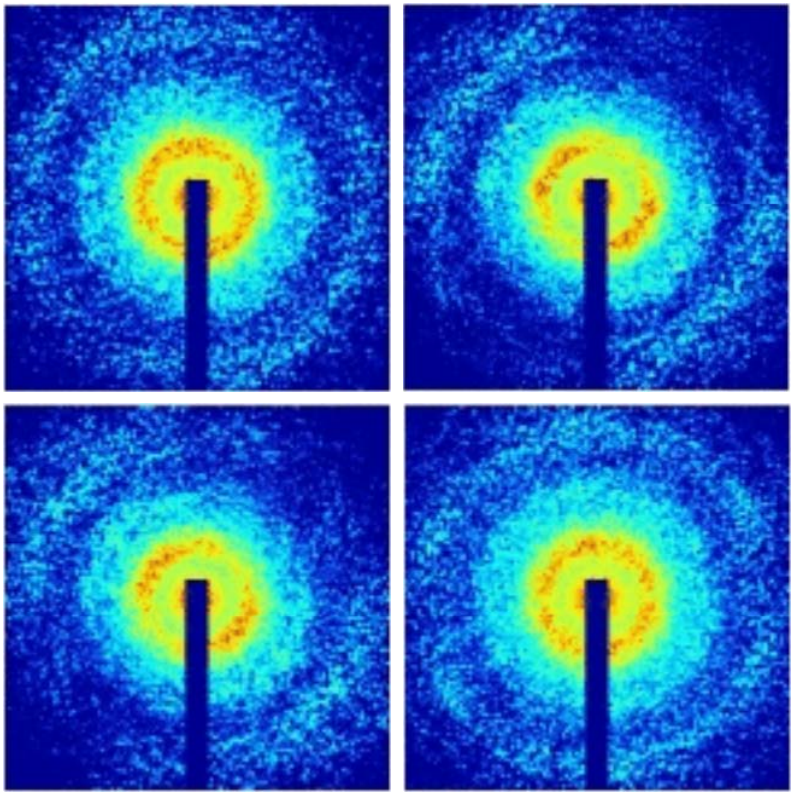

b)
c)
10-2 nm-1

Real Space Reconstruction

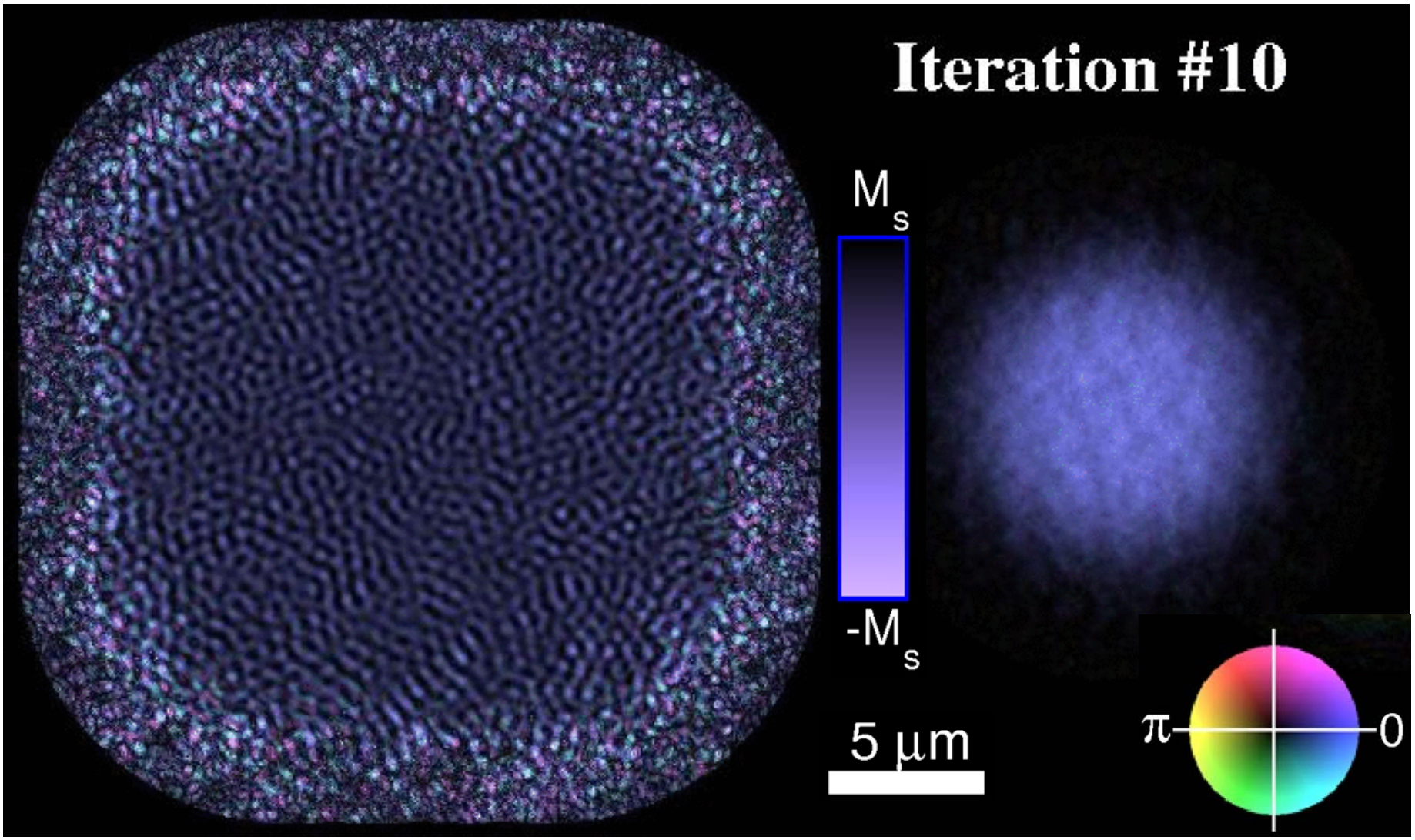


Ptychography

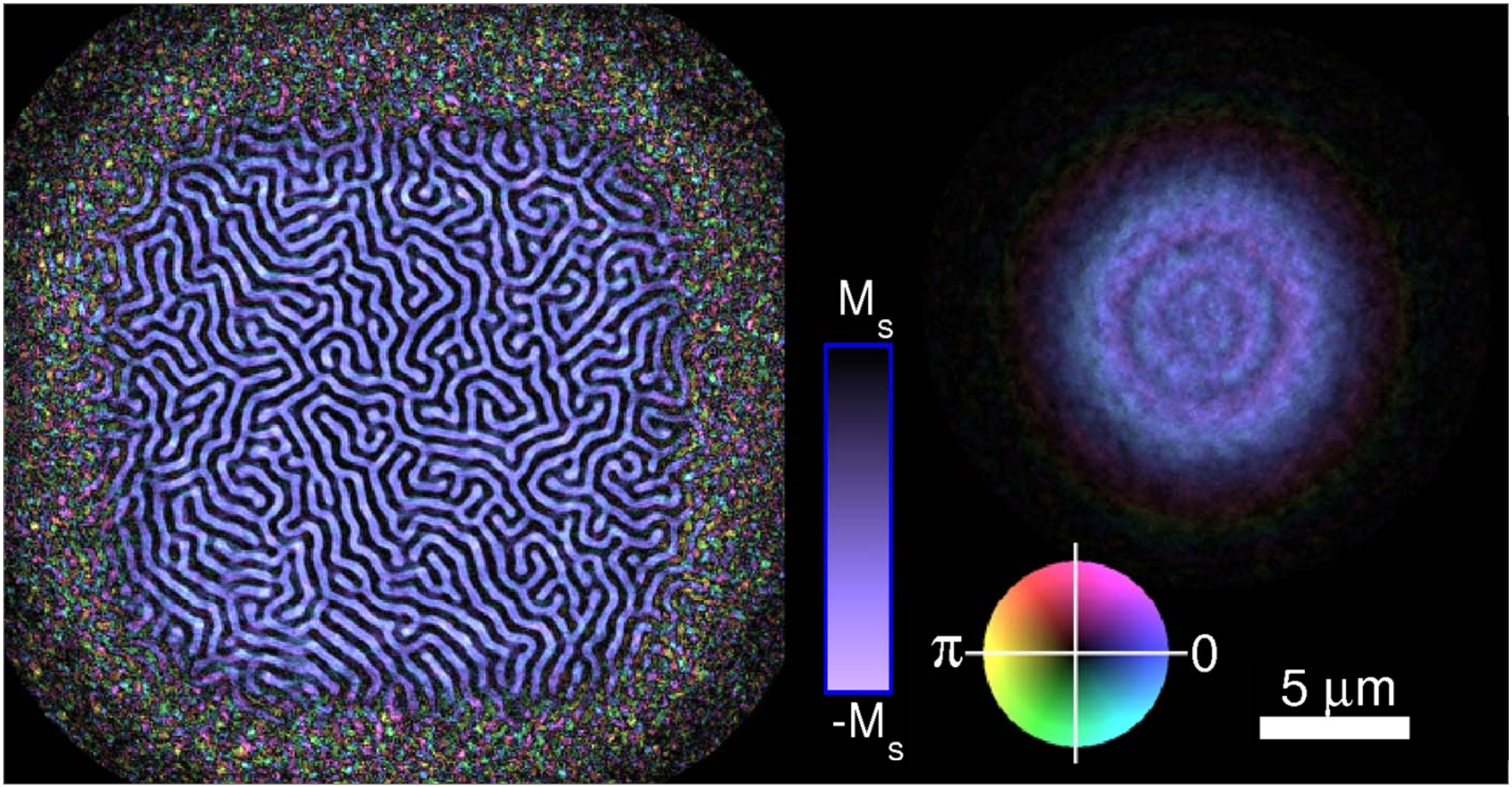




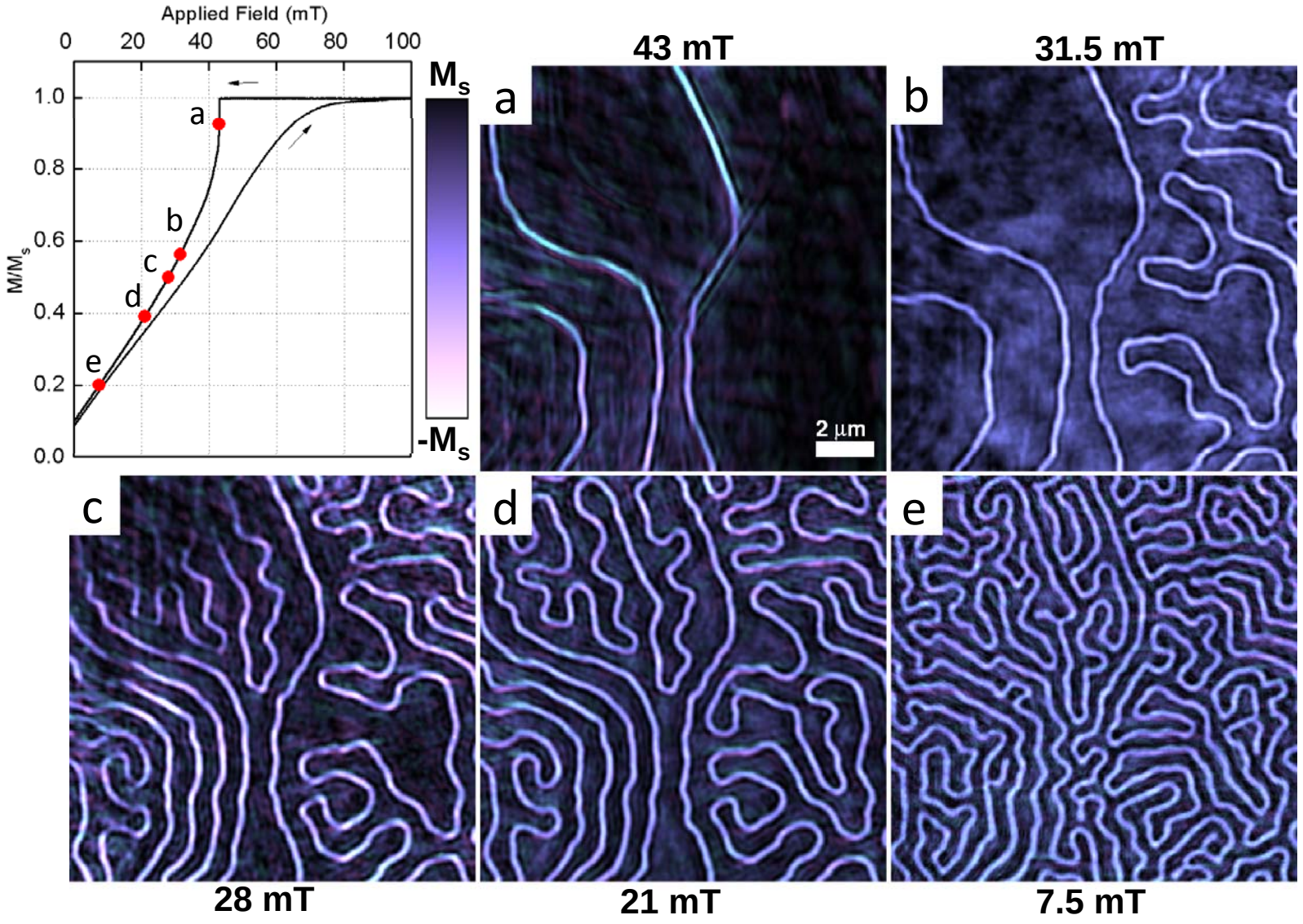
Real Space Reconstruction



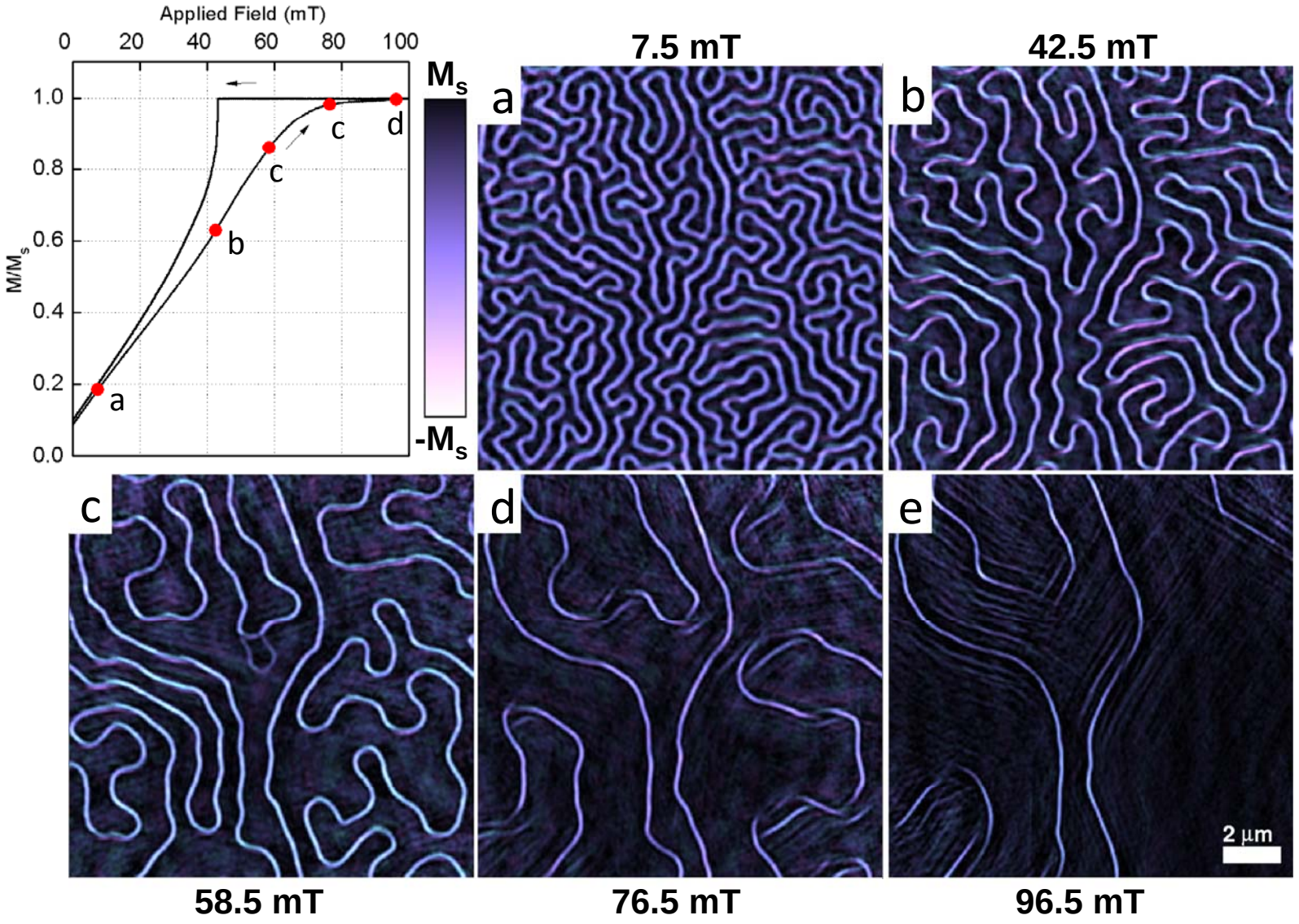
Real Space Reconstruction



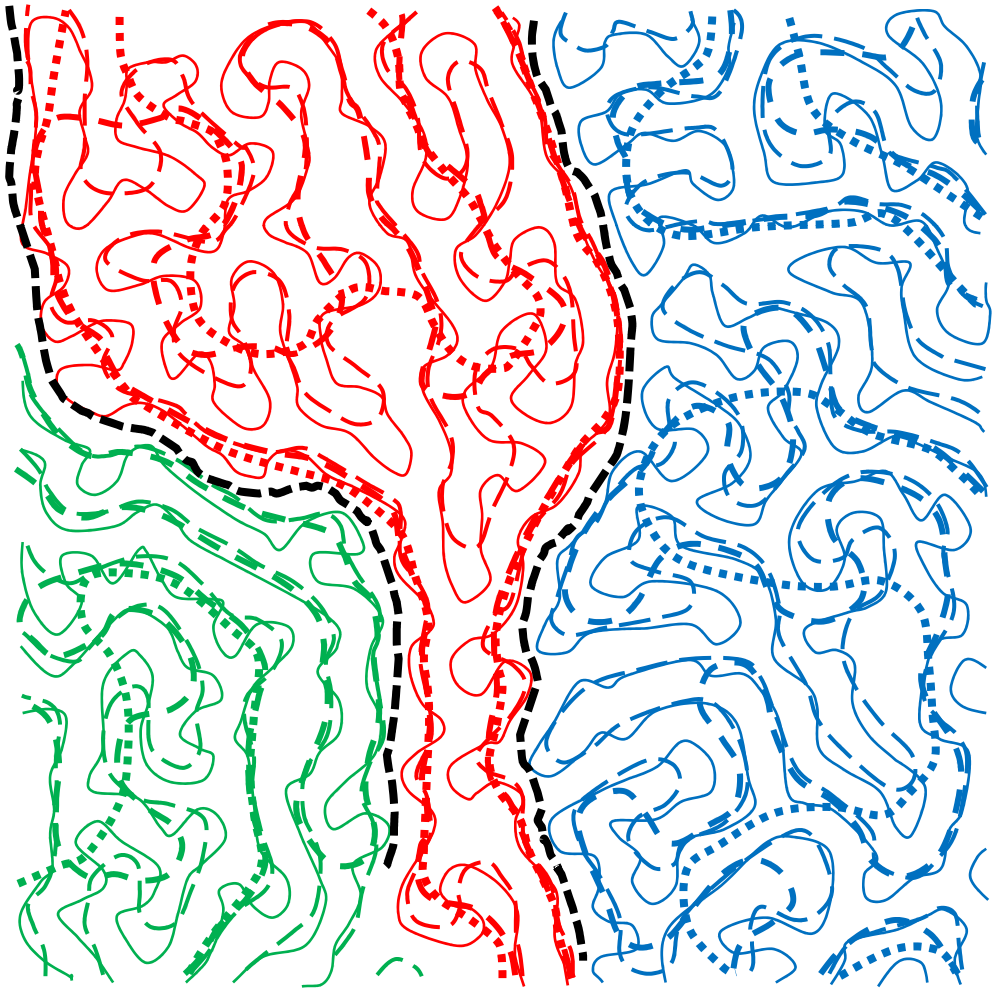
Decreasing Field



Increasing Field



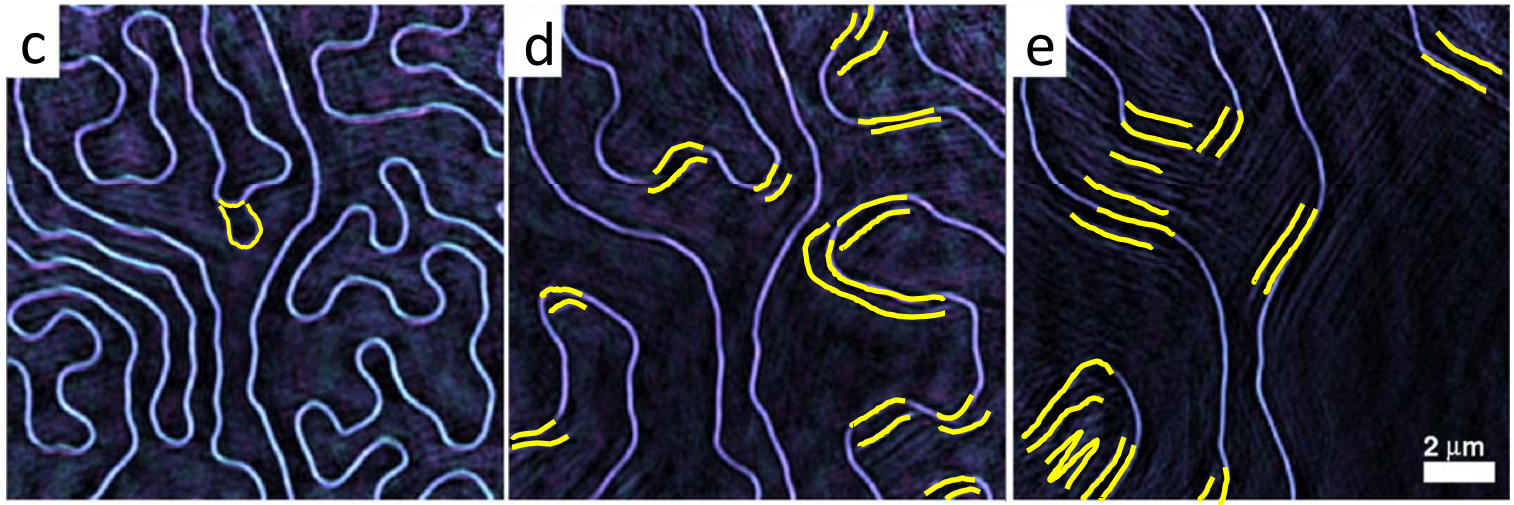
Increasing Field



Evolution of domains occurs in three distinct regions. This indicating a number of pinning sites along the boundary, separating them.

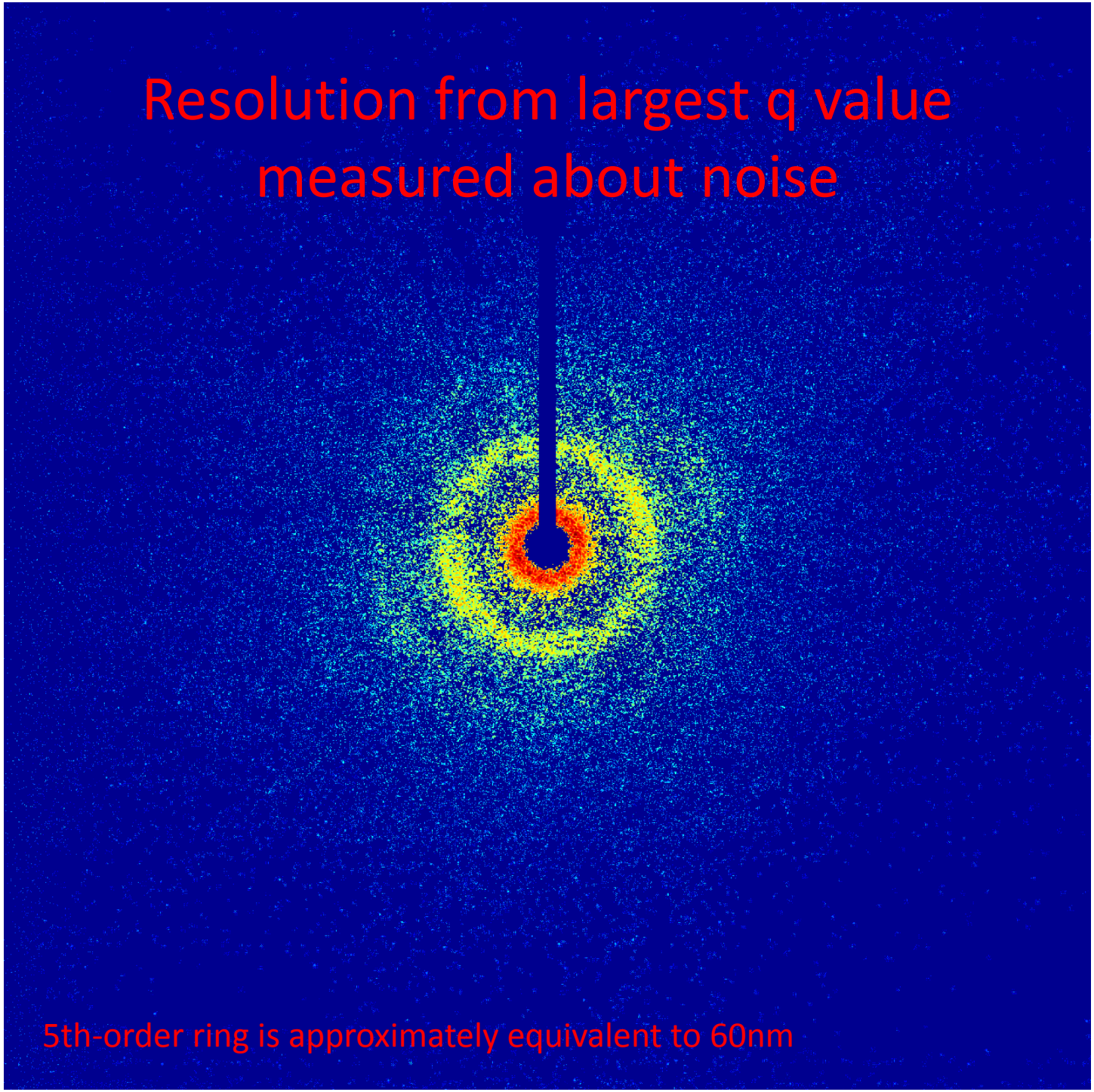
Increasing Field

Small changes in domain configuration are easily picked up in real-space images, which are not easily detected in diffraction patterns. Here, changes are seen as “ghost” domains, indicating intermittent dynamics due to pinning centers.

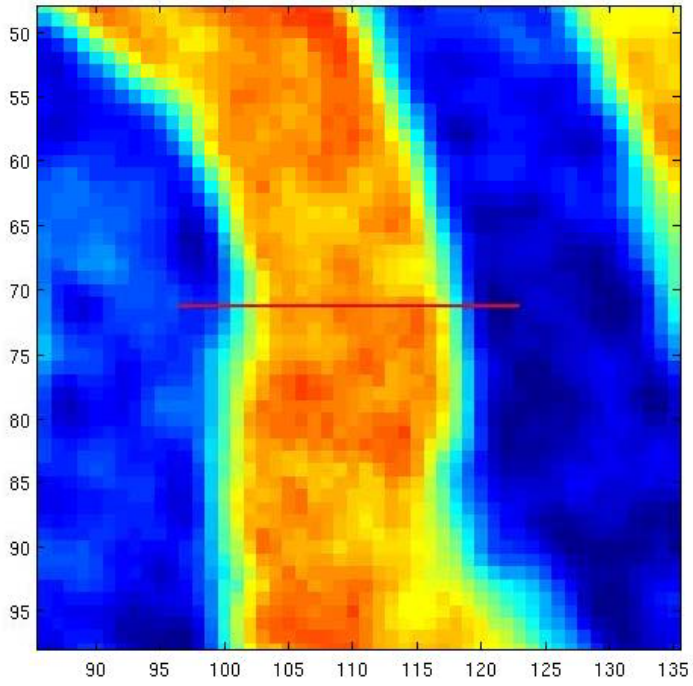


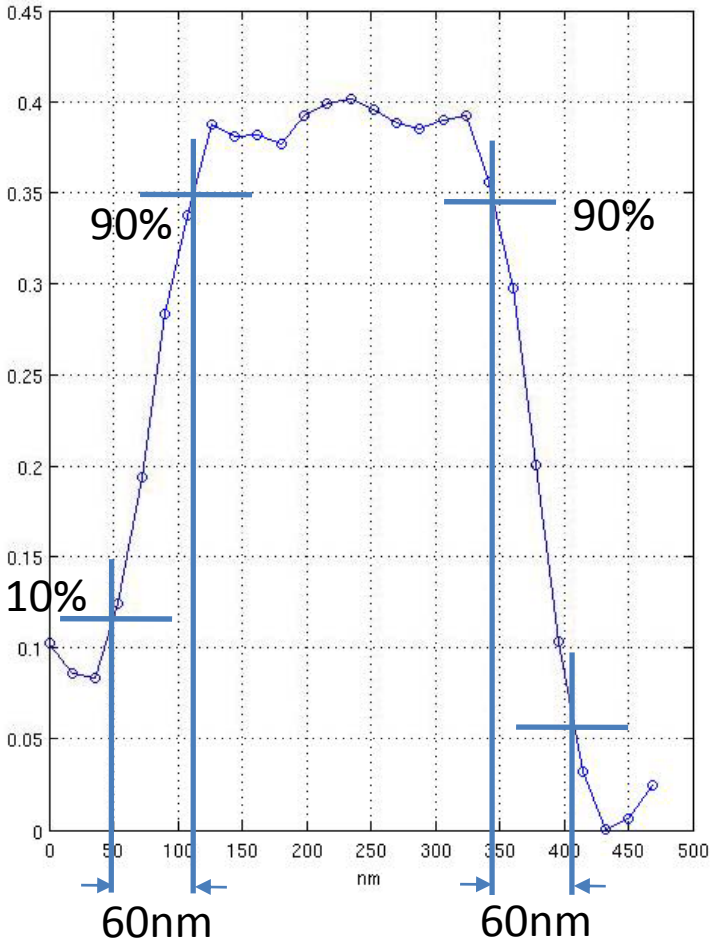
Closing Statements

- Able to use Ptychography to reconstruct real space image from magnetic diffraction pattern.
- Can directly track evolution of domains with external field.
- “Ghost” domains indicate dynamics, which could be further analyzed with XPCS.

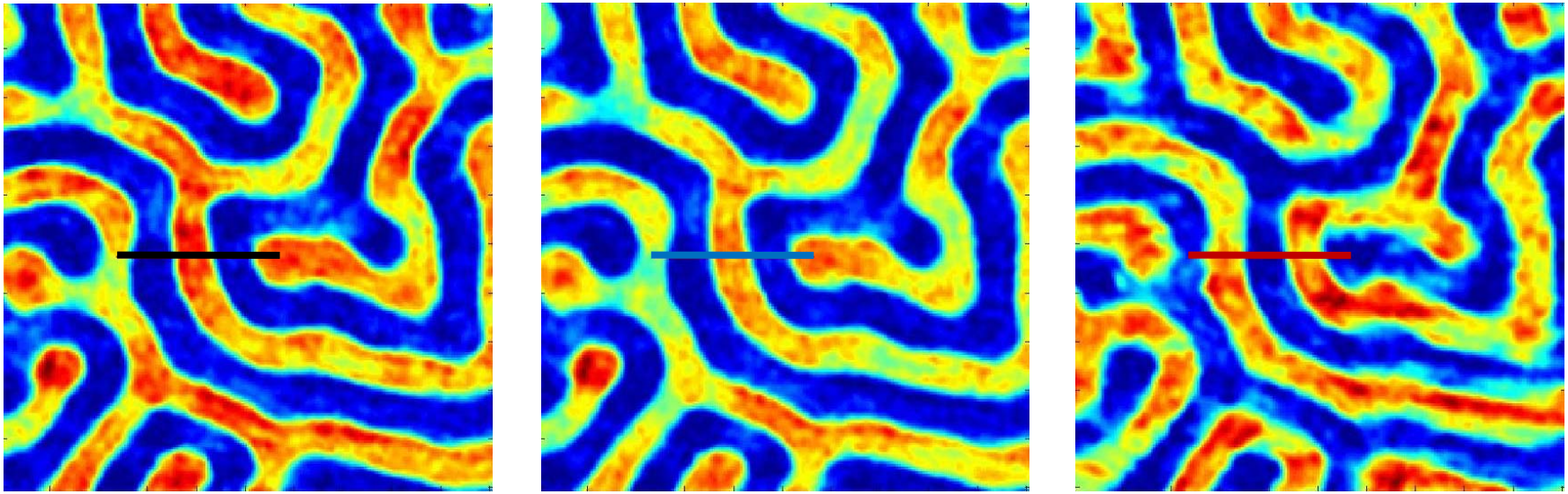

Resolution from largest q value
measured about noise
5th-order ring is approximately equivalent to 60nm

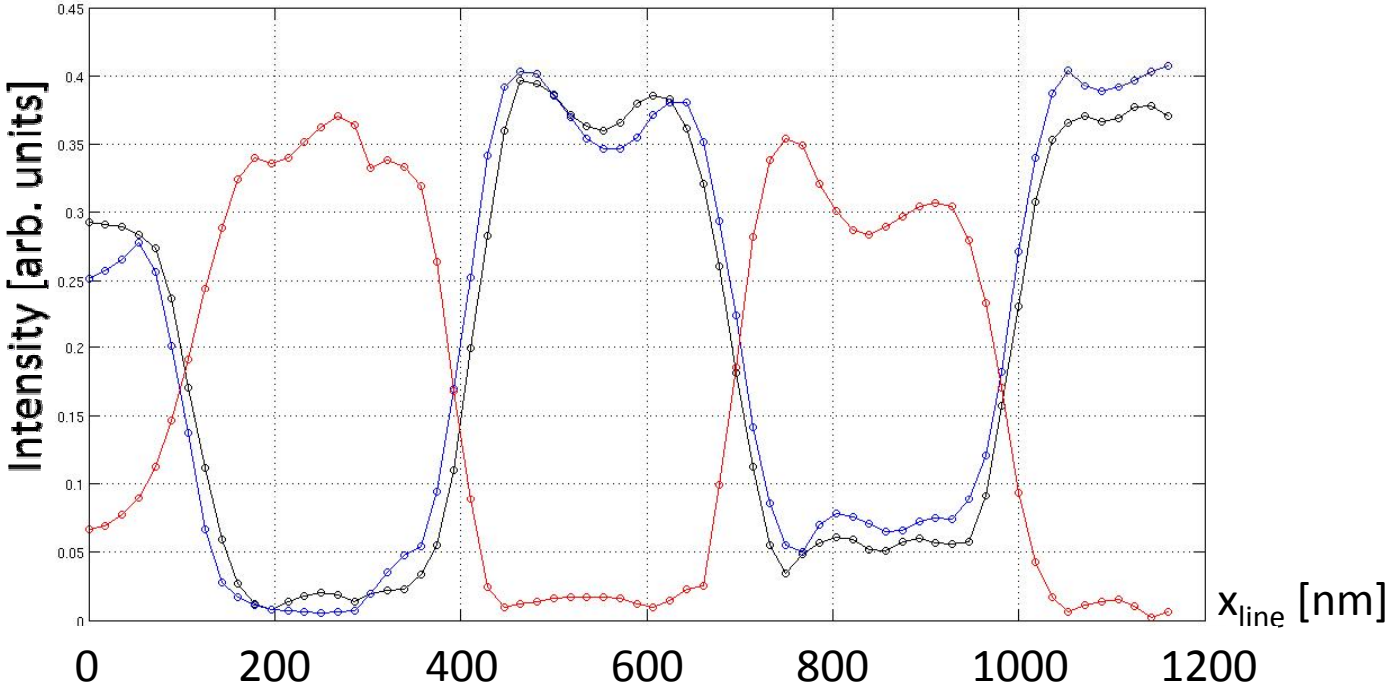
Resolution from 10/90 method



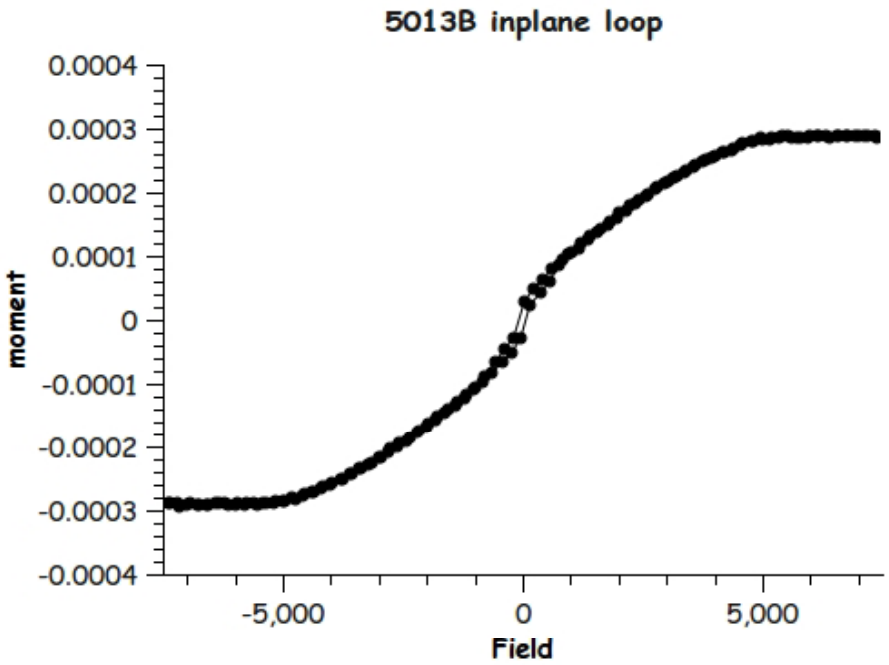


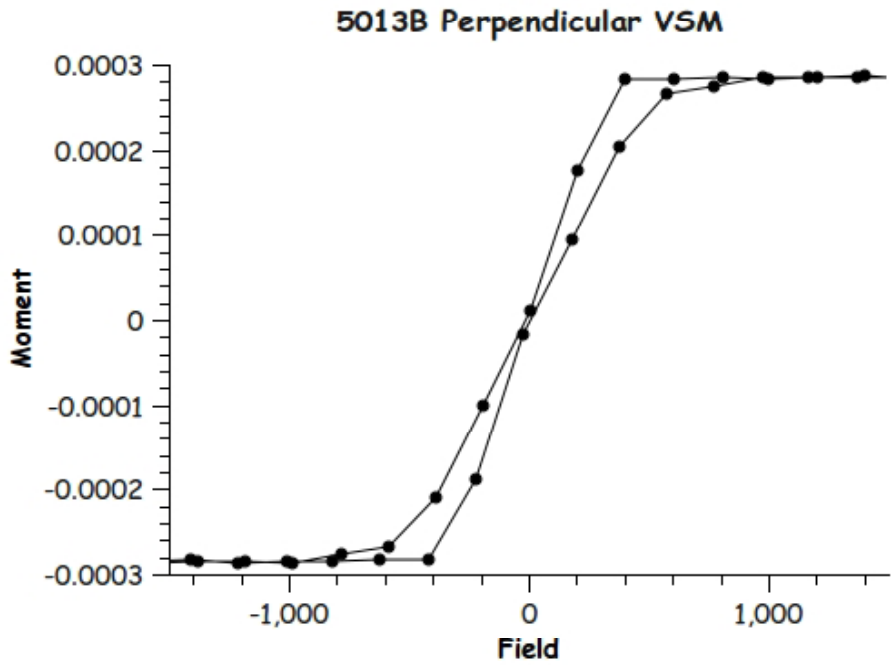
3.6 μm x 3.6 μm reconstructed region



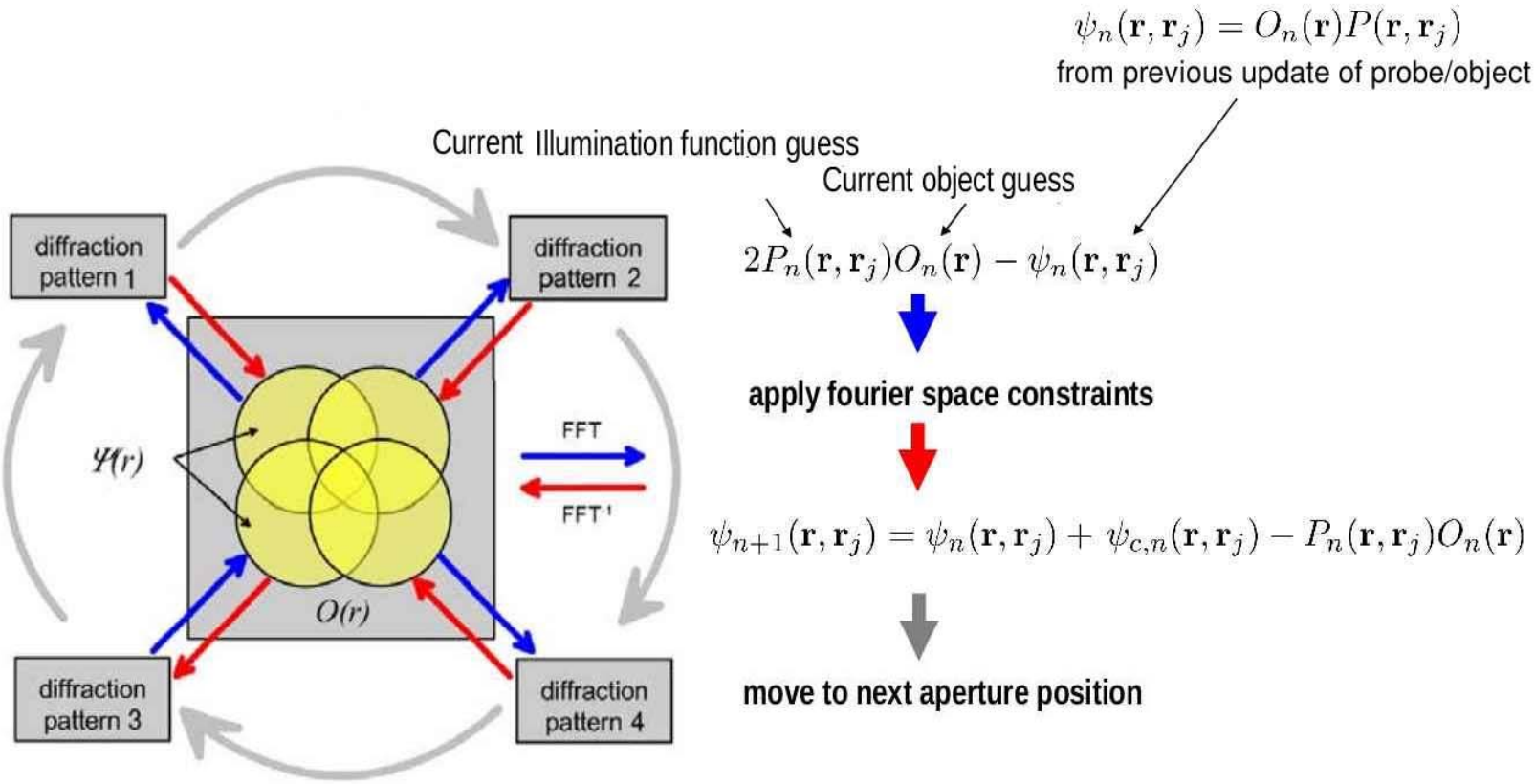


Hysteresis loops using VSM





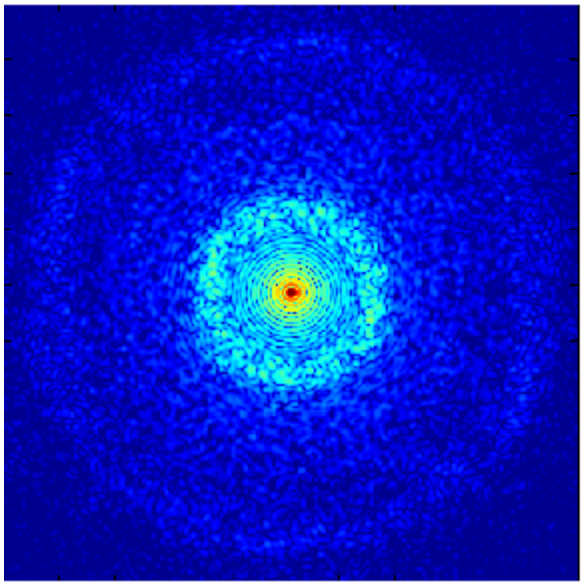
Ptychographical Iterative Engine

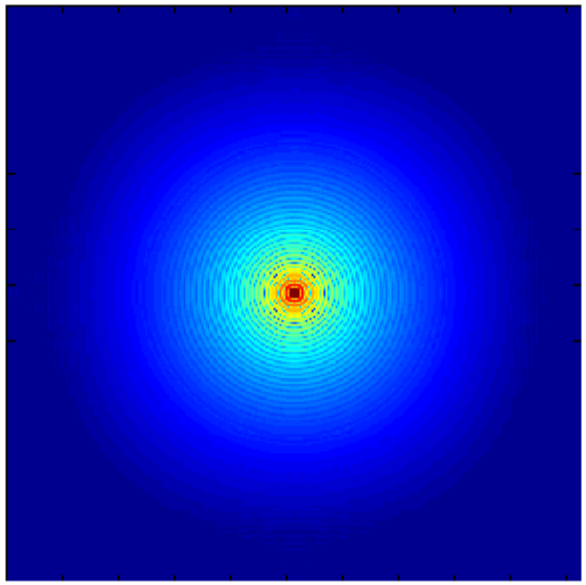


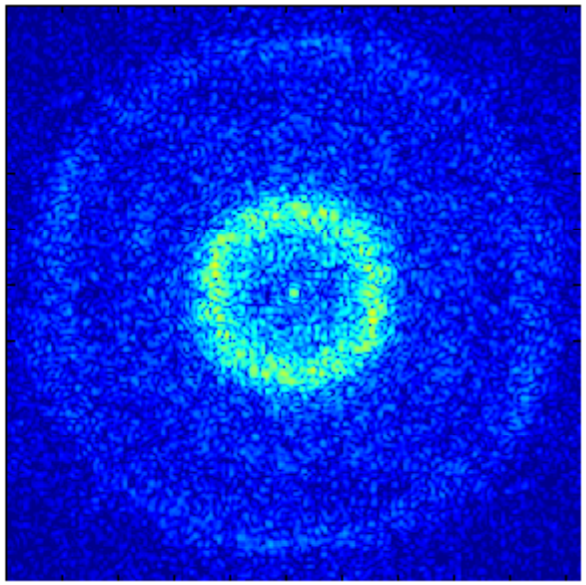
XMCD with linear light and Babinet's principle gives incoherent sum of Charge and Magnetic scattering, allowing us to separate the contributions.

$$I \sim \left| \sum_n e^{i\mathbf{Q}\cdot\mathbf{r}_n} f_n \right|^2$$

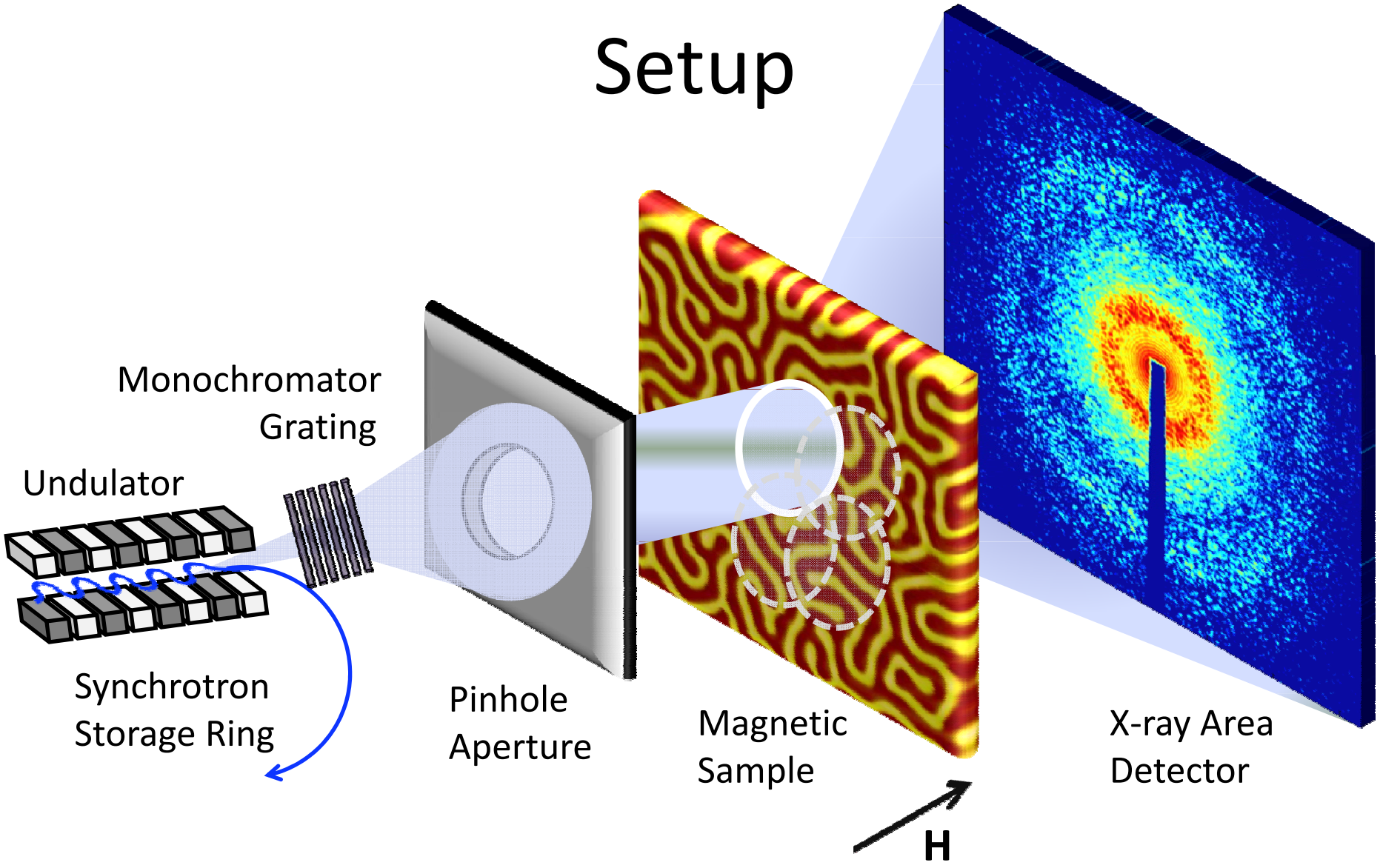
$$= \left| \mathrm{FFT}\left[(f^0_{nonres} + f^{magn}_{nonres} + F^{(0)}) \right] \right|^2 + \left| \mathrm{FFT}\left[F^{(1)} \hat{k} \cdot \hat{m}_n \right] \right|^2$$







Setup



APS sector 2-ID-B